MEDIASTINITIS FOLLOWING CERVICAL SUPPURATION

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INFECTION of the mediastinum may originate from so many different sources and have such divergent manifestations that the term "mediastinitis" means little unless qualified by a description of its type and kind. The process may range from a simple, nonsuppurative inflammation in association with pericarditis, bronchitis, influenza or pneumonia to a very grave, often lethal, diffuse suppurative phlegmon. A chronic variety is seen in tuberculosis which is sometimes called mediastinopericarditis. Tuberculosis also involves the tracheobronchial lymph nodes with occasional suppuration to form a tuberculous mediastinal abscess. These same nodes are infected in many upper respiratory infections, and should they suppurate, a pyogenic mediastinal abscess results. This phase of the subject has recently been emphasized by Lerche.[35] Pyogenic abscesses also follow invasion of the mediastinum from contiguous lung abscesses, empyema, cervical infection, spondylitis, perforating wounds or retroperitoneal infection. These abscesses usually develop slowly enough to allow time for diagnosis, localization and drainage. They have been cured by spontaneous rupture into the trachea or esophagus, repeated aspirations by needle puncture, dorsal mediastinotomy, sternal trephine or cervical drainage. In contrast, a mediastinal phlegmon spreading through so vital a spot may be quickly lethal unless strenuous efforts are undertaken for its control. This diffuse suppuration of the mediastinum may come from any of the sources causing localized abscess if the speed and magnitude of the contamination is sufficient; but the visceral perforations of chest and neck are its commonest cause, and of these the cervical lesions are the most frequent. The consideration of diffuse suppurative mediastinitis might well begin with a study of infections in the neck that gravitate into the mediastinum. This demands a knowledge of the fascial spaces connecting the two, for the infection travels along these and it is in them that the surgeon must intercept or drain it. The spaces lie between layers of the cervical fascia, a structure that is so complex that if followed through all of its ramifications is apt to resemble a maze. The subject may be greatly simplified by considering only that part of the cervical fascia and its spaces which significantly relates to the spread of infection. For this purpose it is sufficient to deal with the viscerovascular compartment which contains the visceral space in the center and around it, the previsceral space, the retrovisceral space and the vascular sheath on either side.

The first experiments designed to study the compartments of the neck were undertaken by Bichat.[2] But many years elapsed before an intensive

investigation by injection methods was made by Henke,[21] König and Riedel,[27] Soltmann,[61] Poulsen[54] and Schmitt.[60] During this period, from 1872 to 1893, most of the essential facts were obtained about the cervical fascia, and the manner of dependent spread of infection along its spaces. For no apparent reason, much of this information has not been referred to in the current literature and references to it are frequently lacking. Some years ago, personal interest in the matter led to anatomic and postmortem dissections in order to study the paths of dependent spread of cervical infection. In doing these the articles of Mosher,[44] Furstenberg[10] and Iglauer[23] were helpful. Recently Coller and Yglesias[7] have reported anatomic studies on this subject.

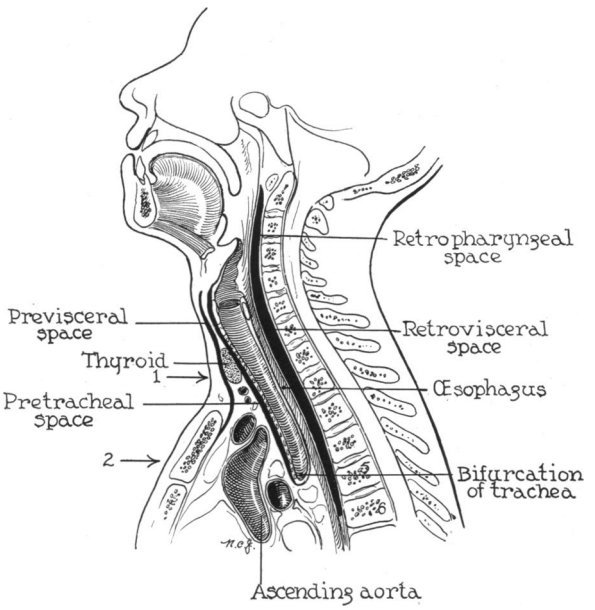

FIG. 1.—A longitudinal section to show the cervical spaces. In front is the previsceral space which ends at the sternum and does not enter the mediastinum. Next is the pretracheal space which conveys infection from tracheal and thyroid gland operations. Behind is the retrovisceral space, the route traveled by pus in 71 per cent of cases of mediastinitis from cervical suppuration. Note that the retropharyngeal space is not separated from it but is only its upper portion. Numerals indicate the level of cross-section, for Figures 2 and 3 of the text.

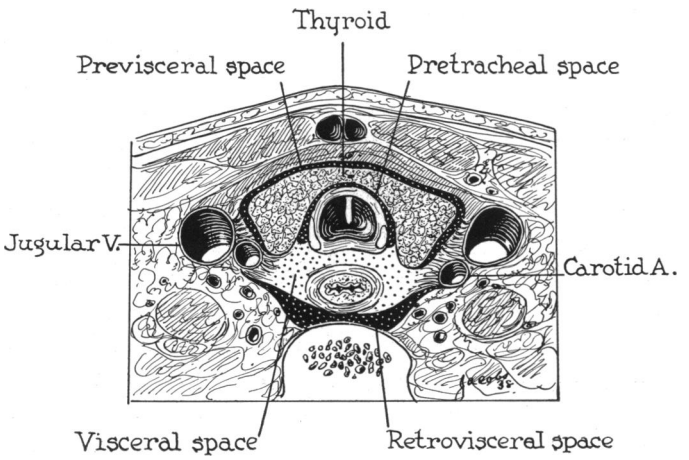

FIG. 2.—A cross-section at the level of the thyroid gland. The visceral space including esophagus, trachea and thyroid gland is a compartment surrounded by the pretracheal fascia in front and the buccopharyngeal fascia behind. In its pretracheal portion is a true space. Behind is the retrovisceral space. Note its relation to the esophagus and cervical spine.

The following summary is an attempt to appraise the facts obtained from the literature in the light of clinical observation and anatomic dissection.

THE VISCEROVASCULAR COMPARTMENT.—That part of the neck occupied by the pharynx, larynx, trachea, esophagus, thyroid and thymus glands, nerves and great vessels is often termed the viscerovascular compartment. It extends from the base of the skull to the mediastinum where it ends by fusion of its fascial structures about the bifurcation of the trachea, the aorta, innominate vein and pericardium. The consideration of this area as a compartment is for the purpose of orientation, since only in its subdivisions are found actual or potential open spaces. These are shown in longitudinal section in Figure 1, and in cross-section, at two levels, in Figures 2 and 3. Reference to these figures will help to clarify the following description.

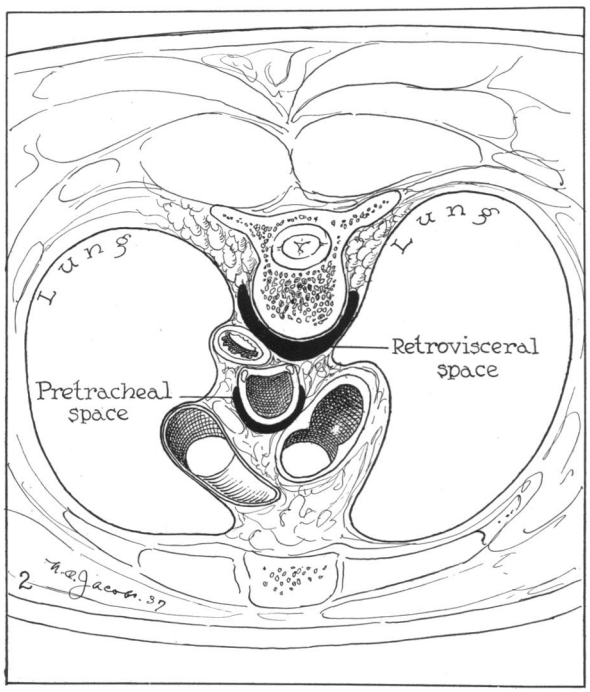

FIG. 3.—Section in the chest at the level of the fifth dorsal vertebra. The retrovisceral space is in close relation to the pleura.

Visceral Space.—The area bounded by the pretracheal fascia in front, the vascular sheath laterally, and the buccopharyngeal fascia behind, which contains the trachea, esophagus, thyroid gland and nerves, is called the visceral space. It is more potential than real, even though its fascial envelope is one continuous layer. The pretracheal fascia which forms its anterior boundary extends from the hyoid bone to the pericardium, splits to enclose the thyroid gland, then merges laterally with the carotid sheath. The same layer is continued behind the pharynx and esophagus as the buccopharyngeal fascia.

In the anterior portion of this compartment, between the posterior leaf of the pretracheal fascia and the trachea, is a free space, often called the pretracheal space, which extends from the larynx to the bifurcation of the trachea. It has no connection with the spaces in the floor of the mouth or those about the pharynx, so does not convey infection from them. The pretracheal space is usually open during the course of a thyroidectomy, and should infection follow the operation, it may gravitate into the mediastinum through this channel. In performing a tracheotomy the space would seem to be contaminated, yet

mediastinitis from this source rarely occurs. Perforating wounds of the larynx and trachea or operations upon these structures may open and contaminate the pretracheal space, with resultant gravitation of infection into the chest.

In Figures 1 and 3 it is seen that the mediastinal portion of the pretracheal space lies behind the great vessels between the arch of the aorta and the trachea. It is apparent that a surgical approach through the sternum would be difficult because of the interposition of these vessels. The approach through the neck entering the space in the suprasternal notch, below the thyroid isthmus, permits its drainage with the least manipulation. Should the mediastinitis follow thyroidectomy, tracheotomy or other operative procedures in this region, then immediate opening of the wound for drainage should be done.

Infection in the visceral space outside of its pretracheal compartment rarely leads to mediastinitis. The fibrous attachments about the vascular sheath, between trachea and esophagus and between the buccopharyngeal fascia and esophagus impede gravitation of the infection. The usual result is a localized abscess. This is most often seen in perforations of the anterior or lateral walls of the esophagus where, instead of a diffuse spreading infection, one finds a localized suppuration requiring only drainage for cure.

The Previsceral Space.—This compartment is familiar to surgeons as the space used in freeing the thyroid gland at operation. It lies beneath the strap muscles and in front of the pretracheal fascia and thyroid gland, extending from the attachment of the sternothyroideus on the thyroid cartilage and trachea down to the manubrium. Furstenberg[10] has emphasized the importance of a process of the pretracheal fascia which attaches to the posterior surface of the sternum and effectively blocks the lower end of the previsceral space. This important attachment prevents infection from reaching the mediastinum.

Carotid Sheath.—There is a difference of opinion as to the importance of this structure in conveying infection into the mediastinum, for on the one hand Mosher[44] says: "the carotid sheath . . . is the natural highway for pus and for the surgeon in pursuit of pus"; while Parsons[51] does not think the sheath exists until it is "manufactured . . . with the scalpel." It is immaterial whether the pus is considered to run down a closed sheath or to burrow along the loose areolar tissue beside the vessels, for in either event the vessels act as a guide for its descent. The infection may arise from a suppurative adenitis of the deep chain of lymphatics in this region or from a suppurative thrombophlebitis of the internal jugular vein. An equally important source is from inflammation in the parapharyngeal space, a triangular cone-shaped compartment with its base at the skull and its apex ending around the carotid artery (Fig. 4). This space may be contaminated from a needle puncture in performing a tonsillectomy under local anesthesia, or tooth extraction with nerve block, or it may be invaded from a dental abscess in the second or third molar. From Figure 5 it is apparent how a parotid, peritonsillar or retropharyngeal abscess may rupture into it. Any of these causes of parapharyngeal

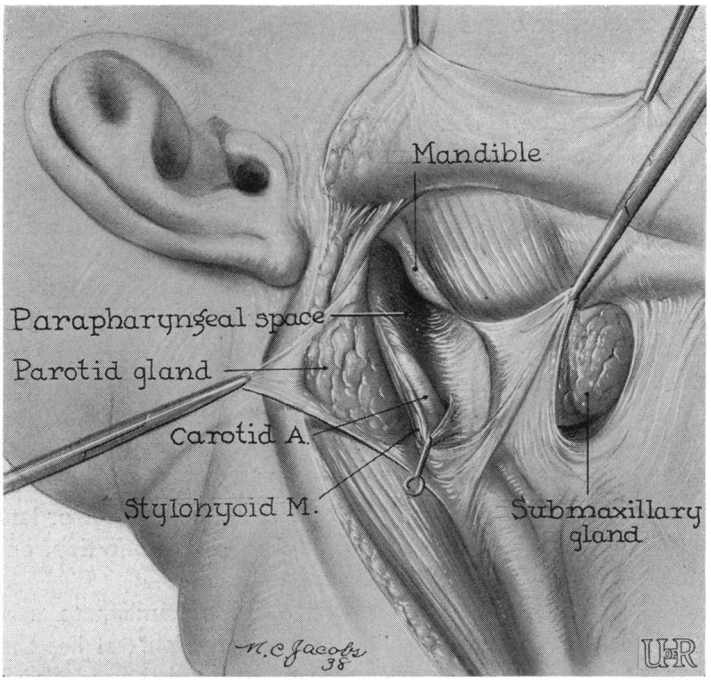

FIG. 4.—The parapharyngeal space seen from the outside. The fused fascia is left in front to separate it from the submaxillary space. The parotid gland is turned back in this dissection for exposure. This could not be done so widely at operation without facial nerve injury. The parapharyngeal space extends up behind the angle of the jaw and ends below around the carotid artery.

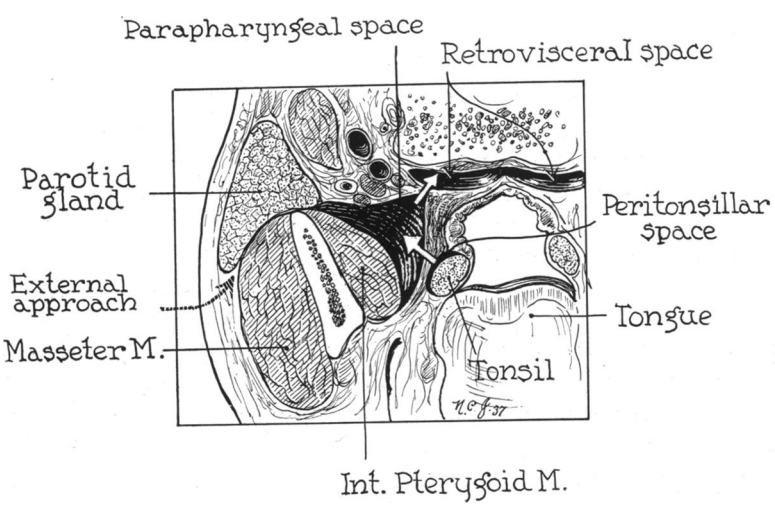

FIG. 5.—The parapharyngeal space may be invaded from a tonsillar, parotid or retropharyngeal infection. Pus from this space may track down the carotid sheath or rupture into the retrovisceral space to involve the mediastinum. (This figure is reprinted through the courtesy of the Journal of the Missouri State Medical Association.)

space infection may result in mediastinitis by gravitation of pus down along the great vessels. Should this occur, warning is given by a rise in temperature and pulse and by tenderness in the neck.

Another pathway from the parapharyngeal space to the mediastinum is by rupture into the retrovisceral space. When this occurs it may be difficult to detect, as was learned to our sorrow in one patient with peritonsillar, parapharyngeal infection who developed mediastinitis without showing any signs in the neck.

Gravitation of pus along the carotid sheath to invade the mediastinum may occur very rarely in Ludwig's angina. This infection involves the sublingual-submaxillary space (Fig. 6) which is closed so completely by muscle or fascia

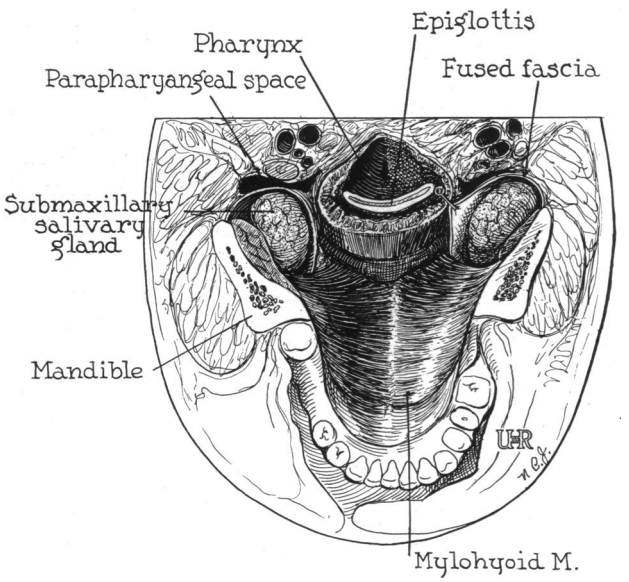

FIG. 6.—The sublingual-submaxillary space, which is involved in Ludwig's angina, is shown by a section through the mouth with the tongue removed. It is separated from the parapharyngeal space behind by the fused fascia which must be eroded through before the infection can gravitate down the neck by this channel.

that no preformed avenue of escape exists. In late, neglected cases the fused fascia may be eroded, allowing drainage of pus into the parapharyngeal space and so down the great vessels or, as was shown by Poulsen,[54] the infection may rupture out along the facial vessels and follow them to the carotid sheath. Both of these possibilities are remote, and in Ludwig's angina the toxemia from infection or respiratory obstruction is more to be feared than mediastinitis.

Retrovisceral Space.—The space behind the pharynx and esophagus is the most important highway of communication between the neck and chest, for it is the route traveled by infection in 70 per cent of the cases. It is bounded by the buccopharyngeal fascia in front, the prevertebral fascia behind, and the carotid sheaths laterally, and extends from the base of the skull to the bifurcation of the trachea. Its lower limit is usually at the level of the sixth dorsal

vertebra, where it is closed by the fibrous tissue about the tracheal bifurcation. Below this obliterated point the space continues to the diaphragm, but this part is not involved in cervical infection. The thin layer of the buccopharyngeal fascia is the only structure separating the pharynx and esophagus from this cavity, therefore, perforation of the posterior wall of these viscera permits direct contamination of the space. This initiates a most rapidly progressive form of mediastinitis, for repeated swallowing forces food, fluid, air and bacteria through the perforation, which mechanically distends the retrovisceral space from top to bottom. In a matter of hours, it may be filled with infected material. The extravasated air can be demonstrated roentgenologically, as is shown in Figure 7, which is a lateral roentgenogram of the neck in a patient with an esophageal perforation.

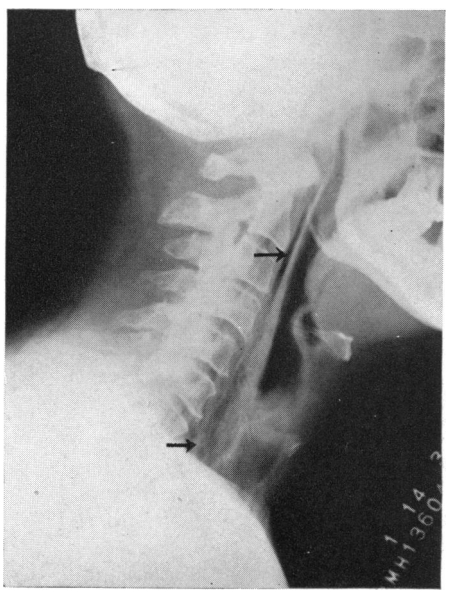

FIG. 7.—The retrovisceral space is defined by air which has escaped into it through a perforation of the esophagus. The upper arrow shows the retropharyngeal part of the cavity while the lower arrow points to a diffuse emphysema in the space.

The retrovisceral space may also be contaminated by an osteomyelitis or tuberculosis of the cervical vertebrae, in which the infection has eroded through the prevertebral fascia. It has been stated that pus in the parapharyngeal space occasionally ruptures into the retrovisceral space rather than following its usual course down the carotid sheath. Another cause of involvement is from gravitation of a retropharyngeal abscess. The retropharyngeal space is only the upper part of the longer retrovisceral compartment and has no true separation from it. At first glance, one might wonder why retropharyngeal abscesses remain so localized in this free space, but when it is recalled that they begin as a suppurative lymphadenitis, it is apparent that the slow development of the inflammation allows it to seal off from the lower part (Fig. 8). Should this obstruction weaken, there is nothing to prevent the infection from sinking into the mediastinum.

INCIDENCE OF SUPPURATIVE MEDIASTINITIS.—The foregoing discussion deals with those cervical infections that may cause mediastinitis and the paths they may take to get into the chest. The question arises, how frequently does this happen? Hare[16] states that: In 520 cases of mediastinal lesions, consisting of benign or malignant tumors, lymphomata, cysts and infections, there were 78 cases of pyogenic suppuration. The majority were from traumatic wounds penetrating the chest or from intrathoracic suppuration and only 17 came from the descent of cervical infection. Using these statistics

as criteria, we find that pyogenic suppuration causes 15 per cent of mediastinal lesions, and that 22 per cent of these infections gravitated from the neck.

The question next arises as to what cervical infections are most apt to produce mediastinitis and what is the relative incidence of each in its causation. In an attempt to answer this, 110 cases of suppurative mediastinitis following infection of the neck have been studied; of these, 99 were obtained from the literature* and 11 from personal experience. They are grouped in order of relative frequency in Table I.

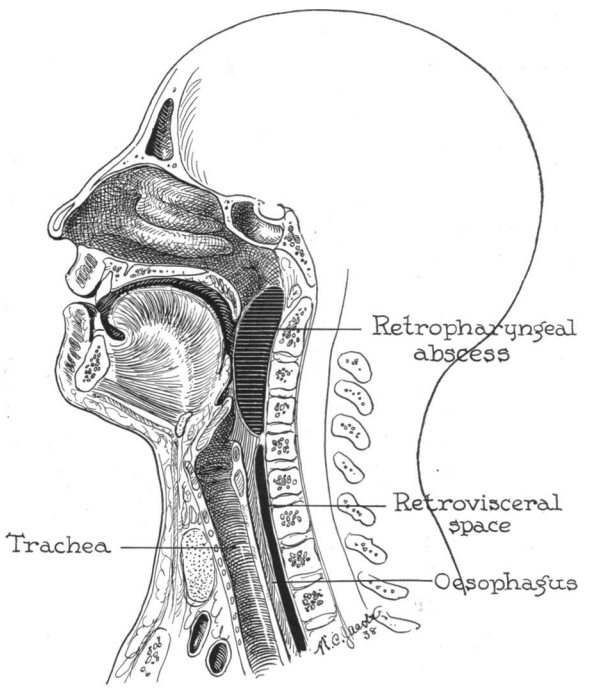

FIG. 8.—A retropharyngeal abscess occurs in the upper part of the retrovisceral space, but the slow development of the suppuration allows walling off of the pus and a separation into two compartments. Should this barrier break, there is nothing to prevent gravitation into the chest.

The data in Table I may be regrouped to show the relative importance of the different paths of spread of pus from the neck to the chest. The retrovisceral space conveys infection from perforation of the esophagus, retropharyngeal abscess and spondylitis of the cervical spine. The carotid sheath conducts it in most instances of suppurative lymphadenitis, peritonsillar abscess and Ludwig's angina. The pretracheal space is the course followed in infection after tracheotomy or thyroidectomy. Listed in this way we find them involved as follows: Retrovisceral space: 78 cases, or 71 per cent;

* All pertinent articles listed under mediastinum in Quarterly Cumulative Index Medicus were searched for cases. It is probable that this list is incomplete, since some may have been published under titles that would not be filled under this classification. The total number is small but perhaps is sufficient to indicate trends.

carotid sheath: 23 cases, or 21 per cent; pretracheal space: 9 cases, or 8 per cent.

TABLE I

110 CASES OF SUPPURATIVE MEDIASTINITIS

Etiologic Factor	No. of Cases	Per Cent	Operative Result		Nonoperative Result	
			Recovery	Death	Recovery	Death
Perforation cervical esophagus	64	58.1	24	9	4	27
Suppurative cervical lymphadenitis	13	11.8	7	6		
Retropharyngeal abscess.	11	10.	6	3	1	1
Peritonsillar abscess	8	7.2	2	2		4
Tracheotomy	6	5.5	1	1	1	3
Spondylitis cervical spine	3	2.8	2			1
Postoperative thyroidectomy	3	2.8	1	2		
Ludwig's angina	2	1.8	1	1		
Total	110		44	24	6	36

In a majority of the cases studied the infection came from perforation of the cervical esophagus. Neuhof,[47] in a report on mediastinal suppuration from both cervical and thoracic sources, found perforation of the esophagus the cause in "almost 50 per cent of the cases." This viscus may be penetrated by external traumatic or surgical wounds, or perforated from within by foreign bodies, bougies, an esophagoscope, or eroded by tumors. The author and Doctor Heatly,[18] in a study on the management of esophageal perforation, decided that immediate external operation is the treatment of choice in order to prevent the occurrence of mediastinal infection and the consequent necessity for its drainage. This view is strengthened by the results of treatment of suppurative mediastinitis shown in Table I. In the 64 cases of perforation of the cervical esophagus, 33 received early operation with nine deaths, a mortality of 27 per cent; while in the 31 cases not operated upon, 27 died, a mortality of 87 per cent.

THE PREVENTION OF MEDIASTINITIS.—The mediastinitis which follows cervical suppuration results from a dependent spread of infection along the fascial planes. If this gravitation of pus could be blocked, the chest infection would be prevented. Reasoning along these lines, von Hacker[15] proposed a prophylactic operation for packing the spaces in the neck. This procedure was popularized by Marschik,[39] and has been described by Palmer[50] and Glogau[13] in this country. Recognition of the importance of the retrovisceral space as a path for the descent of pus led to the development of an operation to block it.[52] These procedures seek to erect a transverse barrier of adhesions across the fascial spaces that connect the neck with the chest. They are indicated in the traumatic visceral perforations, especially of the esophagus

where the progress of the infection is very rapid. Here, even if the surgeon is too late to interrupt the gravitation, he can drain the space and, by releasing tension, prevent extension to the chest.

There is much less indication for prophylactic block of the fascial spaces in the absence of rapidly spreading infection from a visceral perforation. Most suppurations in the submaxillary-submental, parapharyngeal and retropharyngeal spaces or in the carotid sheath are best attacked directly and drained. If the pus has descended in the neck, it will have done so slowly and should be released without destroying the inflammatory adhesions below it. Dissemination of infection might well follow an attempt to do more than this.

MANAGEMENT OF MEDIASTINITIS.—There is every reason to believe that suppuration in the mediastinum should be attacked surgically and drained just as infection in a more accessible location would be. This principle is applicable irrespective of the source of the pus. In the 110 infections which came from the neck, 68 were operated upon with 24 deaths, a mortality of 35 per cent, in contrast to an 85 per cent mortality when operation was not performed. The drainage was accomplished through the esophagoscope in 13, the chest wall in 14 and the neck in 41. There is some controversy among endoscopists as to whether infection should be drained through the endoscope or by external incision. It is probable that the endoscopic approach should be limited to the evacuation of a localized abscess that impinges on the esophagus or presents behind the pharynx.

Incision through the chest wall may be by the anterior or posterior approach. The former is rarely necessary for drainage of infection but the posterior route is useful. The technic of dorsal mediastinotomy is described by Lilienthal,[36] while its historical background is given by Gaudiani.[12] It is the operation of choice in draining suppuration below the level of the sixth dorsal vertebra, and is often advisable in evacuating chronic abscesses of the posterior mediastinum at any level in order to collapse their walls. It is a more formidable procedure than the operation through the neck, which should be used whenever possible.

Cervical mediastinotomy was described by von Hacker,[15] though Lurman[37] reported, in 1876, drainage of a mediastinal abscess that presented in the neck. This operation is the logical approach for drainage of mediastinitis above the level of the sixth dorsal vertebra. That which originates from cervical infection falls in this category and should be so treated, for as Furstenberg[10] states: "To drain an infection through the tissues which it has invaded, is, I believe, a surgical axiom." It has the advantage of allowing direct inspection of the extent and location of the suppuration.

The incision in the neck is usually made parallel to the lower, medial border of the sternocleidomastoid muscle, though it may be placed transversely to follow the skin folds. The sternocleidomastoid is retracted and the fascia lateral to the sternothyroid muscle is divided to expose the carotid sheath and

thyroid gland. The lateral, and perhaps the inferior thyroid, veins are ligated and divided. This allows lateral retraction of the vessels and medial displacement of the thyroid gland, in order to expose the trachea and esophagus. If a short inferior thyroid artery prevents this, it is ligated and divided. At this stage the carotid sheath and pretracheal space may be inspected, but if uninvolved, they are not opened and the dissection is carried behind the esophagus. This opens the retrovisceral space as is shown in Figure 9. If pus is encoun-

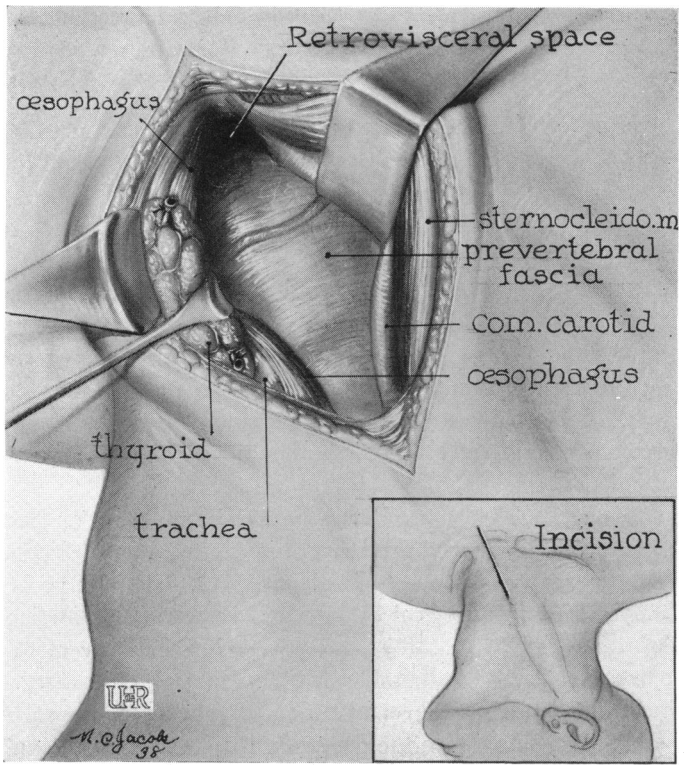

FIG. 9.—Looking down into the posterior mediastinum through the retrovisceral space, as it is seen at operation. Orientation is easier if the drawing is turned so the head is up. The thyroid gland, trachea and esophagus have been retracted mesially, while the carotid artery, jugular vein and sternocleidomastoid muscle are displaced laterally. This exposure permits visual inspection of the space.

tered, it is aspirated and drains are placed to the bottom of the cavity. Some surgeons prefer the approach behind the sternocleidomastoid muscle, but danger of nerve injury is greater in this location. The important factor is to obtain direct drainage, for failure to do this may allow pocketing and residual abscess formation. If the infection has dependent pockets on either side of the midline, they should be drained through separate incisions on the corresponding sides of the neck. A drain crossing the midline is pinched between the spine and the esophagus and causes obstruction to the drainage and abscess formation as is illustrated in Case 1.

Case 1.—Hosp. No. 85308: A female, age 45, was seen 30 hours after an instrumental perforation of the esophagus. The pain, swelling and emphysema were most marked on the left side of the neck, so the incision was made there. But it was found that dependent pockets were present in the mediastinum on both sides, that on the right being the deeper of the two. The patient's condition was very poor, so drains were inserted into both of these cavities and brought out through the incision on the left side. The plan was to perform a second operation on the right side but the patient was too ill to warrant this procedure. She was comatose and aroused only in delirium. The tempera-

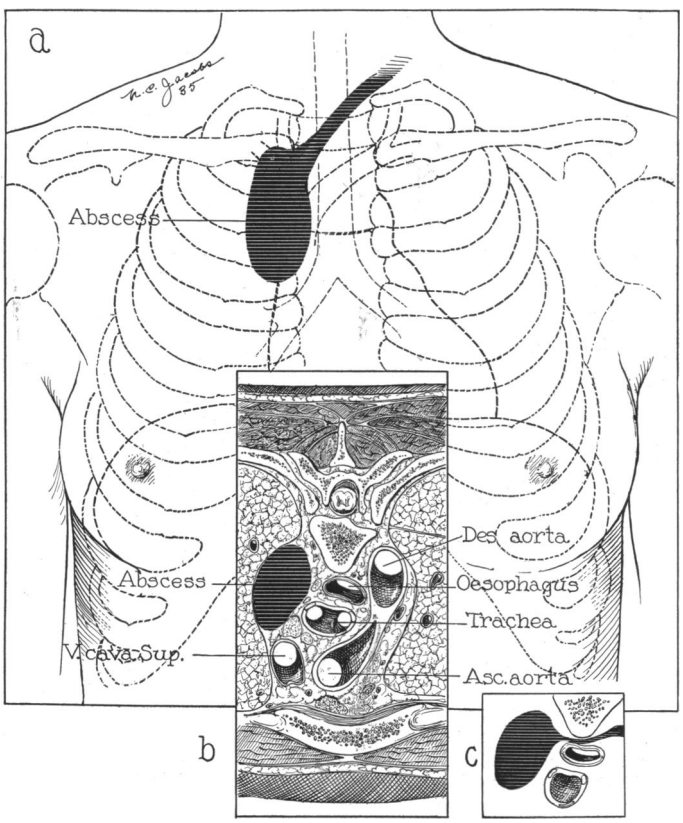

FIG. 10.—Case 1: Residual mediastinal abscess three months after an acute mediastinitis from esophageal perforation. The location in the vertical plane is shown in (a); and in horizontal section in (b). The pinching of the tract between the spine and esophagus is shown in (c). This caused incomplete drainage of the suppuration and allowed the abscess to persist.

ture, pulse and respiration were sustained at a high level. Cyanosis was so marked that an oxygen tent was required constantly. Subcutaneous saline, intravenous glucose, and transfusions were administered, to maintain the fluid balance, while a gastrostomy was performed for feeding. For nine days she held on to life by a narrow margin and then improved rapidly. The fever subsided, mental clarity and physical strength returned and she appeared to be on the road to recovery. Whereas, before she was too sick to drain through the right side, it was now thought that she was too well to need it. This was wrong, for drainage persisted. Injection of the tract showed a residual abscess in the mediastinum. Prolonged attempts were made to drain this by suction through a catheter, but the abscess persisted. Finally, three months after the operation for the mediastinitis, the abscess was drained through the right side of the neck. The patient died six days

after operation of bronchopneumonia, having survived the acute phase of her illness but succumbing to one of its sequelae.

Autopsy revealed a thick-walled abscess cavity, free of pus, situated in the right posterior mediastinum at the level of the aortic arch (Fig. 10). The old drainage tract was compressed between the vertebra and esophagus. The left side of the mediastinum which had received direct drainage was completely healed.

It may be, that it is always more advisable to drain through an incision on the right side, but now after the experience in Case 1, if bilateral pockets are found to exist, both sides of the neck are opened. The exploratory incision should be made on the right side, as anatomic relations make this preferable.

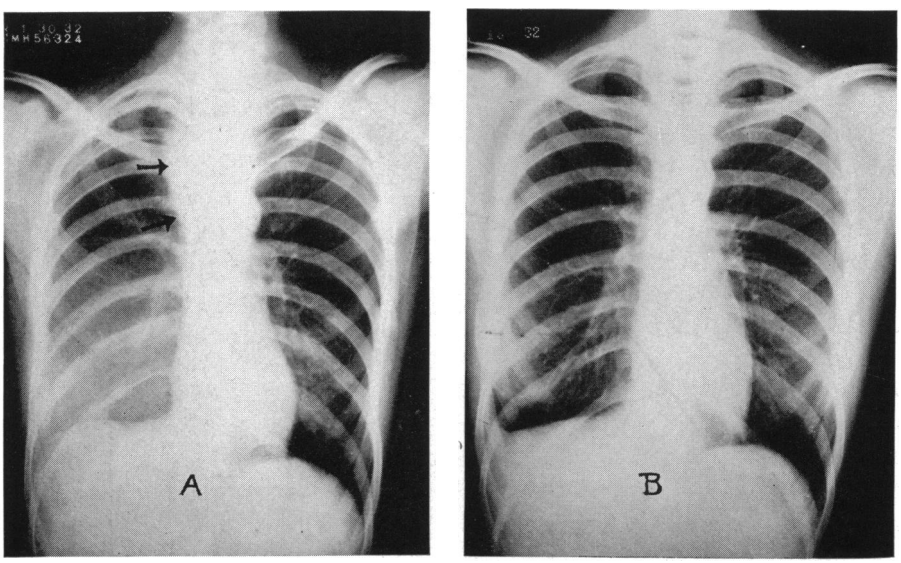

FIG. 11.—Case 2: (A) The arrows point to a residual abscess which has formed during recovery from acute mediastinitis. The pleural edema at the right base is still present. (B) The abscess has been drained and the chest is clear.

The postoperative care of patients with mediastinitis is important, for they are sick and need much supportive treatment. Immediately after operation they should be placed in the Trendelenburg position and kept there until the drainage diminishes or ceases, as otherwise the pus will not run out of the dependent pocket. This position becomes tiresome, but if not maintained may lead to a residual abscess, as happened in Case 2.

Case 2.—Hosp. No. 56324: A female, age 20, lacerated the cervical esophagus with a clam shell. She was operated upon 48 hours after the perforation. Pus was found in the posterior mediastinum. Drainage was established through the incision on the right side of the neck. A gastrostomy was performed the following day for feeding. Fluids were forced by subcutaneous and intravenous infusions. She ran a septic type of temperature, pulse and respiration for one week and then, as these were subsiding, the head of the bed was elevated slightly. Following this the drainage diminished, and the septic phenomena returned. A residual mediastinal abscess (Fig. 11) was demonstrated on the 13th postoperative day, which was drained by inserting a catheter into it

through the wound in the neck. She was returned to the Trendelenburg position, which, combined with aspiration and irrigation through the catheter, resulted in the evacuation of much pus. Her septic course promptly subsided. Drainage ceased at the end of two weeks, and the catheter and gastrostomy tube were removed; feeding by mouth was resumed, and the wound in the neck was allowed to heal. Recovery was uneventful.

This case illustrates the necessity of keeping the patient's head down, in order to provide dependent drainage until the discharge diminishes or ceases.

The mediastinitis which comes from perforation of the pharynx or esophagus may be complicated by the feeding problem. The swallowing of fluids or food, in the presence of an opening in the tract, allows additional extravasation and contamination and should be eliminated. Absolute rest of the esophagus is impossible, for patients will always swallow some saliva. Relative inactivity, however, may be accomplished by employing an indwelling stomach catheter or establishing a gastrostomy. The tube feeding would appear to be the simpler, but it has been tried repeatedly and found to be less satisfactory than a gastrostomy. Artificial feeding is continued until drainage from the mediastinum stops, then liquids and soft solids are tried by mouth before removing the gastrostomy tube. Should an esophageal fistula be suspected, a drink of dilute methylene blue solution will confirm its presence by its appearance on the dressings of the wound in the neck. No difficulty has been experienced with persistent fistula or stricture formation in these traumatic perforations of the esophagus.

The maintenance of an adequate fluid balance is accomplished by the administration of Ringer's solution or glucose given subcutaneously, intravenously or by rectum. Blood transfusion is administered when indicated by the presence of anemia or depletion of serum protein, for either of these may occur in patients who are receiving a low protein intake in the presence of a suppurative infection. Another measure of value is the liberal use of oxygen in the immediate postoperative period, as cyanosis is often present in suppuration of the mediastinum. Some patients show clouding of the lung fields on roentgenologic examination of the chest. This is not ordinarily accompanied by signs of pneumonia and has been attributed to pleural edema. The intimate relation of the pleura and fascial spaces, especially the retrovisceral space, is shown in Figure 3. The pleural reaction with edema varies from a minor degree of thickening to a frank pleurisy and the production of sterile, straw-colored fluid. Repeated examinations have never revealed infection of this exudate and it clears up rapidly with subsidence of the mediastinitis.

The use of the procedures described may be followed by prompt healing if all the factors are favorable. However, in spite of diligent care, some unfavorable circumstances may delay recovery and lead to a protracted convalescence. This is well illustrated in Cases 3 and 4, which are presented for contrast.

Case 3.—Hosp. No. 83591: A married woman, age 21, in normal good health, swallowed a fragment of a toothpick which lodged in the cervical esophagus. The foreign body was removed without difficulty through the esophagoscope by Doctor Heatly. The

sharp point, however, was so firmly embedded in the posterior wall that perforation was feared. This was confirmed by the onset of progressive dysphagia, pain, tenderness and emphysema of the neck, fever and leukocytosis of 29,000, during the following 24 hours. Cervical mediastinotomy was performed through an approach in the right side of the neck, and a fulminating Streptococcus mediastinitis was drained.

Postoperative treatment was given as described except that oxygen was not needed and the establishment of a gastrostomy was delayed, since it was thought to be unnecessary with such a minute perforation. However, on the fifth postoperative day, the presence of material on the dressing, resembling orange juice, led to a methylene blue test which revealed a fistula. Fluids by mouth were stopped and a gastrostomy was performed. The temperature and pulse reached normal on the ninth day; the drainage diminished and finally ceased on the seventeenth day, and feeding by mouth was resumed. Uninterrupted convalescence followed (Fig. 12B).

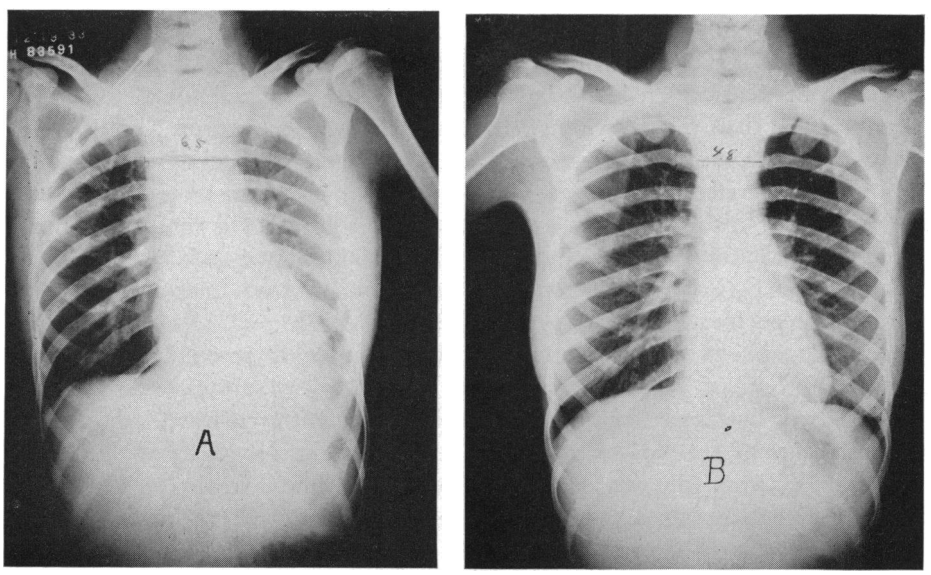

FIG. 12.—(A) Showing the condition, two days after onset, of a suppurative mediastinal infection from esophageal perforation. (B) The appearance of the chest, ten days later, after it had subsided.

This rapid recovery from a virulent infection was no doubt greatly helped by the robust health of this young woman. That the debilitating effect of age and the complication of other disease processes may mitigate against recovery or delay convalescence is well illustrated in Case 4.

Case 4.—Hosp. No. 114,220: A frail woman, age 67, with generalized arteriosclerosis, arteriosclerotic heart disease and cholelithiasis, was admitted for digestive complaints arising from an esophageal diverticulum. Diagnostic esophagoscopy was carried to the opening of the sac but no further. After eating her lunch that day, she developed a chill, fever, leukocytosis, dysphagia, pain, and tenderness; emphysema in the neck soon appeared. A perforation of the esophagus was evident. Operation was performed eight hours after the onset of her first symptom, yet it was found that the retrovisceral space was distended throughout its length with a foul, bloody, purulent fluid containing food particles. This was aspirated out and drains placed to the bottom of the mediastinal cavity. She was placed in an oxygen tent in Trendelenburg position, fluids and blood were given and a gastrostomy established. The temperature, pulse and respiration remained elevated for

25 days, with persistence of drainage from the wound and fistula in the esophagus. The latter was probably continued by the partial obstruction from the diverticulum. Just after her septic phenomena had returned to normal, they rose again in association with right upper quadrant abdominal pain and jaundice (icteric index 50). A diagnosis of common duct stone was made. Fortunately the stone was passed, and the jaundice gradually cleared up during the following nine days. After draining profusely for 40 days, the mediastinal infection began to subside and cleared completely during the next two weeks (Fig. 13B).

In this patient, the debilitating effect of age with its degenerative disorders and the complications of the cholelithiasis and esophageal diverticulum materially retarded recovery.

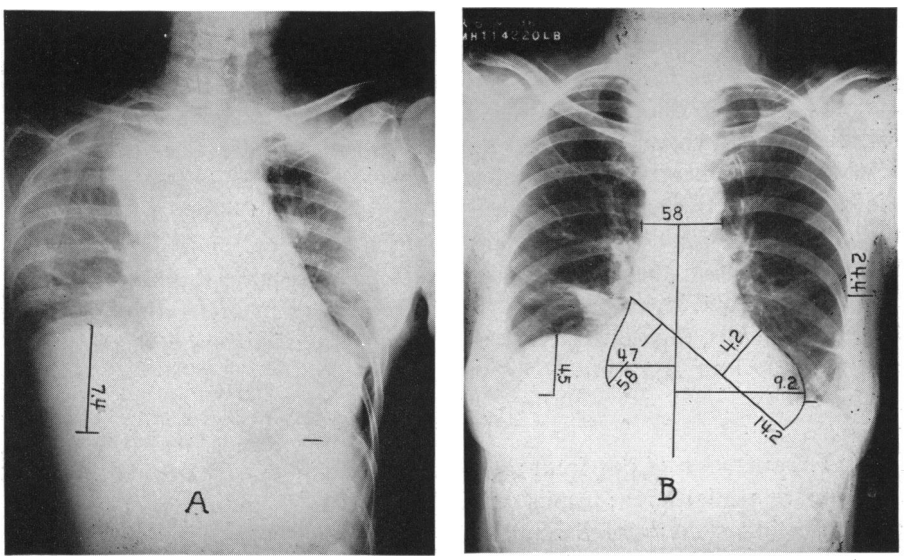

FIG. 13.—Case 4: In (A) an extensive mediastinitis is shown at its worst, while in (B) the process has cleared.

Mediastinitis from cervical sources other than visceral perforation is apt to be slower in its progress and less lethal in its effect. Pus which originates about the mouth or high in the neck, secondary to infection in these regions, tracks down along the fascial spaces slowly enough to give warning. It is often accompanied by an inflammatory reaction in the fascial spaces which produces a barrier to the gravitation of the pus. Care should be used not to break down this barrier at operation, for if it is preserved, recovery will be prompt, as is well illustrated in Case 5.

Case 5.—Hosp. No. 105,448: A robust male, age 17, was admitted with an infection behind the angle of the right mandible, which followed a cold and sore throat two weeks previously. The swelling in the neck was associated with temperature of 40° C., chills, dyspnea, dysphagia and inability to open the mouth. It was drained by the resident surgeon, under the impression that it was a submaxillary space abscess, but in retrospect a parapharyngeal space involvement may have been present. Four days after this operation he had a rise in T.P.R., and complained of tenderness low in the right side of the neck. Operation was advised for descending cervical infection. Thick, yellow pus was

found tracking down mesially to the carotid artery. This showed *Streptococcus hemolyticus* on culture. The cavity extended to the upper part of the mediastinum which was sealed off by inflammatory adhesions. Care was used not to break these down in establishing drainage, and he recovered without further difficulty.

DISCUSSION.—It would appear that suppurative mediastinitis from descending cervical infection is not always a hopeless condition but is amenable to cure if energetic measures are taken to treat it. This requires familiarity with the anatomic arrangement of the cervical fascia, and its spaces, that connect the neck and chest, in order to execute the surgical procedures that are necessary. Persistence in postoperative treatment is most essential.

Anatomic division of the mediastinum by theoretic planes for descriptive purposes is not of much clinical value. Assistance in the solution of practical problems might be gained from dividing the region into four compartments by two planes: the first, a vertical line, would follow the trachea to create the anterior and posterior portions; the second, or horizontal plane, would be at the tracheal bifurcation or about at the level of the sixth dorsal vertebra. This would place the heart and pericardium in the lower anterior quadrant, while the thymus, pretracheal space, substernal thyroid gland, and aberrant parathyroid tumors would be in the upper anterior quadrant. The posterior portion would contain the esophagus and retrovisceral space, the latter divided into its upper and lower portions. From the standpoint of treating suppurative mediastinitis, this concept is useful, for anatomic barriers limit the infection to these four segments.

SUMMARY

(1) Gravitation of pus from the neck causes only one-fifth of the cases of suppurative mediastinitis; in this group, however are found many of the more dangerous infections from visceral perforation.

(2) The paths of dependent spread along the cervical fascial spaces are described. It is found that the suppuration followed the retrovisceral space in 71 per cent, the carotid sheath in 21 per cent, and the pretracheal space in 8 per cent of the cases.

(3) The operative procedures for the prevention and treatment of this type of mediastinitis are discussed. Operation is indicated, as with surgical intervention the mortality is 35 per cent as contrasted with 85 per cent when it is not performed.

(4) Cases of suppurative mediastinitis are presented to illustrate the methods of management of this disorder.

The author's appreciation is expressed to Dr. Clyde A. Heatly, for having made the esophagoscopic examinations, and to Dr. Joseph H. Green, for his roentgenologic work, in the cases reported in this series.

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DISCUSSION.—DR. EDWARD D. CHURCHILL (Boston, Mass.): Perforation of the esophagus by foreign body, or as a result of instrumentation, is as urgent a surgical emergency as a perforated abdominal viscus. The flora of the lumen of the esophagus is as virulent as that of the large bowel. The proper treatment of perforation of the cervical and upper thoracic esophagus is immediate operation by the cervical approach. Operation should not be delayed for the development of signs of local inflammation or roentgenologic evidence of air in the tissues.

Unfortunately, perforation of the esophagus frequently occurs as one of the tragedies of modern medicine—a dangerous and possibly fatal complication of a diagnostic procedure. A perforation of the esophagus by instrumentation must be handled like a perforation of any other viscus. If a surgeon is so unfortunate as to perforate the sigmoid with the endoscope, he knows what he must face and what he must do. Endoscopists must realize that if they find a perforation from a foreign body or if they are unfortunate enough actually to perforate the esophagus with their instrument, proper treatment must be carried out immediately.

I have used the method employed by Doctor Pearse, in an elderly patient with a chicken bone perforation, demonstrated by esophagoscopy. She was diabetic, and operation was performed within 15 hours of the perforation. There was already foul-smelling, thin pus in the retrovisceral space. Recovery followed.

The virtues of posterior mediastinotomy in approaching abscesses of the retrovisceral space must not be overlooked, and while the cervical approach, as Doctor Pearse has shown, is the method of election in perforations of the cervical esophagus and perhaps the upper mediastinal portion of the esophagus, there will be an occasional case where posterior mediastinotomy should be employed. I have performed this twice, and one of the two patients recovered.

A problem that Doctor Pearse did not touch upon, but concerning which we would like information, is the handling of perforations of the esophagus that occur below the level of the bifurcation of the trachea. After infection occurs, the treatment is obvious, but should immediate mediastinotomy be advised if the case is seen early? Usually such a case is seen only after an empyema has developed secondary to a mediastinitis.

Doctor Pearse brings out the problem of feeding, and states that he per-

forms a gastrostomy in many instances. Personally, I have employed a gastric tube which is inserted on the operating table, while a finger can be kept in the incision, and the tube guided past the point of perforation.

There is one other quite rare route for extension of cervical infection into the thorax. Suppuration arising from cervical lymphangitis in the region of the juncture of the great veins just at the thoracic inlet may, instead of descending medially into the mediastina, descend laterally, dissecting the parietal pleura from the endothoracic fascia and present in the axilla, simulating an empyema.

DR. MARTIN B. TINKER (Ithaca, N. Y.): I would like to compliment Doctor Pearse on bringing before this Association this very dangerous and rather difficult complication which is likely to occur to any of us, particularly those who do much surgery in the neck.

A condition which has come to my notice was not mentioned: Extension down the jugular vein of infection in thrombosis of the lateral sinus. Another case had a perforation of the esophagus by an oyster shell, which caused extensive infection; and two cases of neglected suppurative thyroiditis resulted in a serious descending infection. It is unbelievable how rapidly these infections develop in some instances.

DR. HOWARD LILIENTHAL (New York, N. Y.): This is a matter which, as a thoracic surgeon, has interested me tremendously. I have written a little about it and you will find some points which have been brought out by this excellent paper of Doctor Pearse's in a book that I[1] wrote, which appeared 13 years ago.

Although I have discussed this repeatedly since that time, it appears to me that surgeons in general are afraid of the mediastinum. I believe that if there is a history which points to the possibility of this complication, it is better not to wait, particularly when the patient is very ill. Posterior mediastinotomy is not nearly as dangerous as many seem to believe. If no infection happens to be encountered, there is, with proper precautions, almost no likelihood that it will become infected from the exploration. Posterior mediastinotomy affords an excellent exposure.

I would emphasize one or two points in regard to this form of exploration: (1) If there is a history of endoscopy, especially of the esophagus, one should early suspect involvement of the mediastinum, and one should not fear mediastinotomy by the posterior approach. If the suspected lesion is in the lower part of the esophagus, exploration is just as necessary as when it is in the part with which Doctor Pearse's paper especially deals.

Gunshot wounds may also infect the mediastinum, posterior or anterior, and even operations for goiter have been known to be followed by this complication; although I myself have seen only one. I agree with the speaker about the importance of inverting the patient, but in some instances where this is difficult, a multifenestrated tube placed through the upper wound into the space and equipped with a suction apparatus will be effective. This will often make a secondary procedure unnecessary. It should also be borne in mind that in the lower third of the chest the right pleura often, in fact usually, extends over the midline into the left. Therefore, in opening the lower part of the mediastinum, especially on the left side, beware of the overlapping right pleura, or there may be a fatal infection of both cavities.

Another useful function, if one may so denominate it, of posterior mediastinotomy is the opening of certain lung abscesses which point here. I have done this several times.

Finally, I would urge that the possibility of suppurative mediastinitis should be borne in mind, even though roentgenologic examination does not reveal it.

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DR. JOHN ALEXANDER (Ann Arbor, Mich.): May I offer, as a corollary to Doctor Pearse's presentation, a suggestion as to the choice between cervical drainage and thoracic drainage of these abscesses? I have used both approaches and have been satisfied with both, but I feel one should choose the approach according to the case. May I suggest that in those which are operated upon quite early after the beginning of the infection, and are located high in the mediastinum or low in the neck, the cervical approach is obviously the better; but those that have localized as far down as the fifth or sixth thoracic spine, particularly when the case is a relatively old one, let us say more than two or three weeks old, and particularly when there is evidence that some foreign body has lodged in the abscess, a posterior mediastinotomy is the better approach.

I feel that in a case that has become subacute or chronic, prolonged cervical drainage through a tube which lies close to the carotid sheath may possibly cause an erosion of the carotid artery and fatal hemorrhage, whereas, prolonged drainage through a wide posterior mediastinal incision, with packing of that incision, presents almost no danger of pressure necrosis of a large vessel.

As Doctor Lilienthal has said, the opening of the mediastinum is simple in cases in which there is a large abscess that projects on either side of the spine, or bilaterally. The parietal pleura will have been dissected away from the mediastinum by the abscess, so that a resection of two or three inches of two posterior ribs together with the transverse vertebral processes, and a division of the intervening intercostal bundle, permit one to enter the abscess directly. If a foreign body has dropped into the bottom of such an abscess, or is imbedded in the soft tissues, it would be difficult to safely remove it if one attempted to do so through the more or less long track which would have been produced through a cervical incision.

In summarizing, I suggest the use of a cervical incision in acute cases and in those in which the infection, particularly free pus, has not extended as far as the fifth or sixth thoracic spine, but a posterior thoracic incision for older cases which will probably require prolonged drainage and those in which a foreign body may have become lodged in the abscess in a position that is relatively inaccessible through a cervical incision.

DR. OWEN H. WANGENSTEEN (Minneapolis, Minn.): This presentation by Doctor Pearse is an important one. There is one point which I should like to make concerning early recognition of perforation of the esophagus. Doctors Pearse and Churchill both indicated that there was often much delay between the occurrence of this tragedy and its identification. Whereas, considerable time may elapse before subcutaneous emphysema becomes appreciable by palpation, yet, the presence of air in the interstitial tissues about the esophagus can usually be detected in a roentgenogram a few minutes after its escape from the esophagus. I would, therefore, strongly urge that all cases in which perforation of the esophagus is suspicioned have a roentgenogram made immediately of the neck and thorax in order to identify the possible presence of air. Such a film can be repeated if necessary after a short elapse of time.

A hospital visitor with a self-inflicted bullet wound through the neck, who had shot a hospital patient through the chest, was seen by me several years ago, a short time after the shooting. The offender presented no evidence of hemorrhage or nerve injury and there was no subcutaneous emphysema. He was hustled off to jail and died a few days later, I learned subsequently, from mediastinitis resulting from perforation of the esophagus. Since then, I have looked for evidence of escaped air from the esophagus in a roentgenogram rather than with the palpating hand. In the drowsy small hours of the night, I have once made the diagnosis of spontaneous perforation of the lower esophagus over the telephone in conversation with the surgical resident, on the basis of subcutaneous emphysema in a patient who had upper abdominal pain, no dyspnea or cough. The roentgenogram, as I have indicated, is, however, a much earlier and a better determinant of the presence of air in the para-esophageal interstitial tissues.

I would like to cite an unfortunate happening attending operative closure of a cervical perforation of the esophagus which occurred after esophagoscopy, in the interest of those who may be disposed to try something of the sort. At the time of operation, the thought occurred to me that if the carotid sheath were opened and the smooth inner surface of that sheath sutured over the site of suture of the perforation, the risk of mediastinitis would be lessened. The patient was maintained in the Trendelenburg posture and no mediastinal abscess developed. The patient's convalescence seemed assured, and somewhat more than a week later, I withdrew a soft rubber tissue drain (Penrose) which had been left in the wound. A slight blood stain was noted on the dressing subsequently, but a few hours later the patient died suddenly from profuse bleeding from the wound. I had anticipated finding the source of hemorrhage in an intervertebral vein or from the left internal jugular at postmortem. Much to my astonishment and amazement, however, the erosion was in the common carotid artery. Whereas, the use of the carotid sheath may secure the esophageal suture line, it is decidedly not a safe procedure.

This experience leads me to make a brief digression. It seems a bit odd that the thick walled artery should have ruptured rather than one of the adjacent thin walled veins. It seems to me that this very occurrence sheds some light upon the shortness of our years. Our arteries are called upon to sustain a relatively great pressure unrelentingly over years. Is it not likely that arteriosclerosis may be largely a traumatic process? If it is metabolic in origin, who do not veins exhibit these age changes in the same measure as it is observed in arteries? It may well be that the biblical three score and ten years are determined by the length of time that arteries will withstand the effects of systolic blood pressure.

I have had a single experience with an esophageal fistula resulting from pressure by a mediastinal abscess. What astounded me most about it was the great difficulty in securing closure of the fistula. After the performance of gastrostomy, I waited months for it to close spontaneously; no esophageal obstruction could be demonstrated. Yet this fistula stayed open until a very extensive decostalization, performed in stages, closed eventually both a total empyema and the esophageal fistula.

DR. HERMAN E. PEARSE (closing): Doctor Churchill has brought up the matter of after-care, particularly in relation to the feeding of patients with esophageal lesions. This is very important, for fluid balance must be maintained; blood is often needed, not only to supply hemoglobin but also deficient serum protein and oxygen may be required for prolonged periods in a tent.

Feeding may be difficult. I have had a discouraging experience with the duodenal tube, largely because the patient is already uncomfortable from the wound, the manipulation of the oxygen tent, and the administration of fluids. I have tried it repeatedly and have now returned to a gastrostomy as the simplest procedure.

I would agree entirely with Doctors Churchill's and Alexander's presentation that these patients must be individualized, and if I may be allowed to predict, I believe that with more experience, we will divide them into three groups: One will constitute those infections which slowly gravitate down fascial planes from the neck. They should be simply opened and drained. Nature's barrier against the spread of infection should not be broken down. In the next group are those who have either a spreading infection or a localized abscess below the level of the fifth or sixth dorsal vertebra. They certainly should be attacked through the chest wall. The fascial spaces from the neck extend only to the level of the sixth vertebra, so one cannot use the cervical incision for those at the lower level. The same approach should be used for long-standing abscesses in any location, for they need some collapsing of the chest wall in order to obliterate the cavity.

The third group are those described who have a virulent spreading suppuration from a visceral perforation. Their treatment must be much more energetic than for a localized abscess, and if the perforation is above the sixth dorsal vertebra, the mediastinum should be drained immediately through the neck.

I have never encountered the complication of hemorrhage spoken of by Doctors Alexander and Wangensteen. We all know that Doctor Halsted devised a very ingenious method for the gradual occlusion of great vessels with an aluminum band. He stated that he had cured aneurysms but some patients died of hemorrhage; therefore, it has long been known that gradual pressure on a pulsating vessel will wear away its wall.

Two factors might increase the risk of hemorrhage: One is the dissection of the carotid artery to expose its wall in the incision. This is not necessary. It should be left alone with its fascial envelope intact. The second is the use of a hard drainage tube. In any experience I have had in operative vascular surgery, I have never seen soft material erode a vessel wall.